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METHODS OF PROJECTING BIRTHS.

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THIS NOTE DESCRIBES AND CRITICIZES THE VARIOUS METHODS CURRENTLY IN USE FOR PROJECTING BIRTHS--(1) COHORT-FERTILITY, (2) AGE-SPECIFIC, (3) COHORT-FERTILITY (SCRIPPS), AND (4) MARRIAGE-PARITY-PROGRESSION. VARIABLES USED IN THE VARIOUS METHODS ARE AGE OF MOTHER, COMPLETED FERTILITY, MARRIAGE STATUS, TIME SINCE MARRIAGE, PARITY, AND BIRTH INTERVAL. THE COHORT-FERTILITY METHOD EMPHASIZES THE ANALYSIS OF FERTILITY IN TERMS OF SUCCESSIVE GENERATIONS OF WOMEN AS THEY ACHIEVE CERTAIN AGE LEVELS DURING THEIR CHILDBEARING YEARS. THE AGE-SPECIFIC METHOD USES AGE OF WOMEN AS ITS ONLY VARIABLE. THE SCRIPPS COHORT-FERTILITY REFINES THE COHORT-FERTILITY METHOD BY CONSIDERING THE PROPORTION OF WOMEN MARRIED BY AGE GROUP. THE MARRIAGE-PARITY-PROGRESSION SEQUENTIALLY ESTIMATES MARRIAGES, FIRST BIRTHS, AND EACH SUBSEQUENT BIRTH BY A SCHEME OF ACTUARIALLY COMPUTED PROBABILITIES OF MARRYING AND OF BEARING CHILDREN OF EACH SUCCESSIVELY HIGHER ORDER. AN OVERVIEW IS GIVEN OF RECENT TRENDS IN BIRTH PROJECTION MODELING EFFORTS AND NEW APPROACHES TO THE PROBLEM OF PREDICTING FERTILITY. (HW)

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METHODS OF PROJECTING BIRTHS

The turtle lives 'twixt plated decks
Which practically conceal its sex,
I think it clever of the turtle
In such a fix to be so fertile.

---Ogden Nash

INTRODUCTION

This Note presents the various methods currently in use for projecting births. In particular, the basic method used by the Bureau of the Census (cohort-fertility method) and three alternative methods--age-specific, cohort-fertility (Scripps), marriage-parity-progression under investigation by the Bureau are described. Finally, an overview is given of recent trends in birth projection modeling efforts and new approaches to the problem of predicting fertility. This Note does not enter the tenuous area of actual prediction of the future course of birth rates, but merely describes the methods used currently in prediction.

DESCRIPTION OF METHODS

A. Relevant Variables in Fertility

Before considering the various methods of birth projections, listed below are some of the possible factors pertinent to fertility:

1. age of mother
2. completed fertility history
3. marital status
4. time since marriage
5. parity (i.e., number of previous children born)
6. birth interval or spacing (i.e., number of months since birth of previous child)

The various methods of birth projections may be considered according

to which of the above variables are taken into account, and the procedures and assumptions employed in using them. Table 1 presents the variables used by each of the methods for projecting births described in this paper:

Table 1.-Variables Incorporated in Various Methods of Birth Projection

Method	Age of Mother	Completed Fertility	Marriage Status	Time Since Marriage	Parity	Birth Interval
Age-Specific	X					
Cohort Fertility (Census)	X	X				
Cohort Fertility (Scripps)	X	X	X			
Marriage-Parity-Progression	X	X	X	X	X	X

B. Bureau of Census' Cohort-Fertility Method

Since 1964, the Bureau of the Census has used an approach known as the "cohort-fertility method" originally explored by the late Pascal K. Whelpton and Norman B. Ryder. In this method, the fertility history of cohorts of women (i.e., women born in the same year) are traced as they progress through the childbearing ages (age 14 to age 50). Thus, the number of births occurring to any group of women at each age and the total number born by the end of the childbearing period are known.

The cohort-fertility method emphasizes the analysis of fertility in terms of successive generations of women as they achieve certain age levels during their childbearing years. Thus, of the above lists of pertinent variables, only historical births by series of age of

mother consistent with completed fertility is directly considered in cohort-fertility. Other variables, however, are in all probability included implicitly in one or more of the series of cohort-fertility projections employed. For example, age at marriage is an important determinant in total number of children ever born.

Since actual completed births may be used as a yardstick, the cohort-fertility method at least provides degree-of-magnitude ("ball-park") guidelines so that unreasonable or unlikely projections may be avoided. For any given projection period, since the number of children women at each age have already had is known, estimates of future births may also be guided by the results of national sample surveys concerning expected family size.[3/] Expressed birth expectations, however, may be unreliable because of changing circumstances, especially for cohorts who have not yet entered the childbearing ages. Further, even if completed family size can be stated within fairly narrow limits, additional assumptions must be made concerning the timing element which determines the actual total number of births for a given year.

Generally, four sets of projections, designated Series "A", "B", "C", and "D" have been made by the Census Bureau in recent years. Series "A" continues the highest fertility rate since World War II,

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3/ Growth of American Families Studies conducted by the Scripps Foundation for Research in Population Problems and the University of Michigan Survey Research Center and evaluated in: P.K. Whelpton, A.A. Campbell, and J.E. Patterson, Fertility and Family Planning in the United States, Princeton University Press, Princeton, 1966.

while Series "B" and "C" provide upper and lower bounds for the results of the 1960 Growth of American Families Study on expected size of completed family. Series "D" reflects the lowest completed fertility rates experienced by cohorts born in this century, excluding those who experienced their major childbearing years during the depression years of the 1930's. (See Table 2, page 5).

In summary, then, for cohort-fertility projections, the following steps are taken:

1. For each annual cohort of women in the childbearing ages, assumptions are developed of completed fertility (total number of children born/woman).

2. Births are distributed year by year over the childbearing span for each cohort of women according to the pattern of age-specific birth rates shown in reasonably representative past years.

C. Age-Specific Method

In the age-specific birth projection method, the only variable involved is age of women. The number of children born in a calendar year, for example, to mothers at each of various age levels is projected, using as a guide the performance of past histories of women. This method was used until recently (1964) by the Census Bureau but since then it has been discarded in favor of cohort-fertility.

D. Scripps' Cohort-Fertility

Another method described by the Census Bureau is one developed by the Scripps Foundation for Resarch in Population Problems. As the name implies, it is essentially similar to the Census' cohort-fertility

Table 2.-Actual and Projected Number of Births for Various Projection Methods

	Actual [1]	Age Specific [2]	Cohort Fertility [3]	Cohort Fertility [4]	Marriage-Parity Progression [5]
1963-64	4142	4423	4422	4219	4277
1964-65	3948	4533	4527	4260	4276
1965-66	3678	4663	4648	4326	4294
1966-67		4808	4777	4409	4334
1967-68		4959	4908	4476	4382
1968-69		5112	5039	4579	4444
1969-70		5270	5172	4714	4510

1/ Number of births for 1963-64 and 1964-65 from U. S. Bureau of the Census, Population Estimates, Series P-25, No. 345, July 29, 1966; births for 1965-66 from U.S. Department of Health, Education and Welfare Monthly Vital Statistics Report, October 6, 1966.

2/ Assuming continuation of average age-specific birth rates during 1960-63. See Appendix C, Population Estimates, Series P-25, No. 286, July 1964.

3/ Series "A" (highest series). See Table 1, Population Estimates, Series P-25, No. 286, July 1964.

4/ Series "B" (medium high). This series is used in Office of Education projections of students.

5/ High Series, see Appendix E, Population Estimates, Series P-25, No. 286, July 1964.

since fertility rates for individual cohorts of women are considered. In addition to fertility rates, however, Scripps' method includes a further refinement in its projections by considering the proportion of women married by each age. Various levels of projections are provided by varying the proportion of women who marry, the size of completed family, and the distribution of birth rates by age of mother over the childbearing span.

E. Marriage-Parity-Progression Method

This method developed by Wilson H. Grabill of the Census Bureau takes direct account of the variables of marriage, parity (number of previous children born), and birth interval, or number of months since previous child. In this procedure, marriages, then first births, then second births, etc., are sequentially estimated by a scheme of actuarially computed probabilities of marrying and then of bearing children of each successively higher order.

For this method, the essential steps consist of:

1. Computation of age-specific probabilities (constant for immediately projected years) of first marriage among single women (Source: 1960 Census data), then applying them to women in the childbearing ages only;

2. The preceding computations are then decreased by appropriate survival rates;
3. Next, estimation of a parity-interval-specific birth probability, i.e., for women at each age-specific level the probability that women who have x number of children ($x \geq 0$) will have $x+1$ during the next 12 months, if the last previous child was born m months ago. Thus, these probabilities are of the following: The probability that a 28 year old woman, mother of two children, the last born two years previously (birth interval = 24 months), will conceive and bear

a child within the next 12 month period. If she has a child then the woman is advanced to parity 3 and birth interval zero. If she does not conceive then there is no increase in parity and the woman remains in parity 2, but her birth interval is advanced 12 months to birth interval 36 months. Thus, the marriage-parity-progression method may be thought of as a measure of the cycle of events through which a woman passes in forming her family.

CRITIQUE OF BIRTH PROJECTION METHODS

In cohort-fertility, since the total number of births for a given cohort of women is assumed to be known, long-term trends or completed fertility is established immediately. For example, the cohort of women born in 1920 will eventually have x number of children. Episodic factors, such as wars and depressions, thus will have little effect on the ultimate size of family. In age-specific fertility, short-term periodic fluctuations will be reflected in the annual number of births for a given age group of women.

Older median age of mothers, however, does have a major effect on total number of future births in the long run, since the childbearing period is shortened.[4/] Median age of mothers has not varied a great deal over the past 50 years, varying from a low of 24.8 years for women born about 1935 to a high of 27.4 years for women born about 1915, or a range of approximately 2.6 years. Yet, it has been estimated that if the older median age for mothers should prevail again

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4/ Ansley J. Coale and C.Y. Tye, "The Significance of Age Patterns of Fertility in High Fertility Populations", Milbank Memorial Fund Quarterly, October 1961.

as in 1915, there would be a total loss of births of approximately seven million in the next 20 years.[5/]

Shortcomings of these various methods for predicting births may be enumerated in terms of the relevant variables involved in fertility (cf. Table 1). For example, age-specific methods do not account for marital status, time since marriage, parity, completed fertility or number of months since previous birth. The distribution of births by age of mother according to the elapsed time since previous birth is of utmost concern, since the probability of birth diminishes rapidly when conception does not take place within, say, five years after the birth of a child.

Thus, Grabill's method which accounts for marriage, age, parity, and interval between successive births should prove to be more predictive and accurate than those methods which do not take direct account of the above variables. Indeed, the marriage-parity-progression method did indicate the direction of movement of births from 1963-64 to 1965-66 far better than the cohort-fertility method (which actually predicted a much greater increase in births during the same period). However, Grabill's method did not project the drastic drop in actual births for 1965-66. The difference amounted to over 0.6 million, and the possible improvements for this lack of predictability are discussed in the next section.

5/ Donald S. Akers, "Cohort Fertility versus Parity Progression as Methods of Projecting Births," Demography, 1965, Volume 2.

RECENT DEVELOPMENTS

Although elaborate models increase the difficulties of computational methods and, more importantly, difficulties of conceptualization, this is the direction that the newer projective models are taking. Greater specificity and depth of a great many more variables comprise the content of current models. The development of fertility rates which are specific not only for age, parity, marriage, birth interval, etc., which were discussed earlier, but for occupation, socioeconomic class, and contraceptive usage have been explored. Also, investigators are taking a closer look at biological determinants such as the probability of conception per unit time (fecundability), the probability that a conception leads to a live birth, the amount of time lost from reproduction as a result of birth (or miscarriage), and the total duration of the reproductive period.[6/]

In some instances, biological models have revealed some interesting, interactional aspects of biological data. For example, the possibility exists that changes in elapsed time after the most recent birth to the next conception may be a sensitive indicator of changing natality trends.[7/]

6/ E.B. Perrin and M.C. Sheps, "Human Reproduction: Stochastic Process," Biometrics, Vol. XX (1964), 2845. R.E. Potter and J.M. Sakoda, "A Computer Model of Family Building Based on Expected Values", Demography Vol. III, No. 2 (1966), 450-461.

7/ L. Henry, "Fecondite et famille", Population, Vol. XVI (1961), 27-48, 261-82.

Thus, natural fecundability is apparently subject to considerable variation, a situation which calls for further explorations of interactions among related biological variables.

Simulation models which can be acceptable as experimental surrogates for specified populations are in various stages of development. So far, only selected features of certain empirical data have been reproduced by them.[8/] On such systems, the ability to modify variables and to include new ones makes possible "experiments" which can be compared with actual past outcomes and for possible projective uses. The development of electronic computers has made such experiments practicable and extended the horizon for further dimensions in the development of mathematical models.

ADDENDUM

In recent months, much has been publicized about the possible role of newer birth control methods and their effects on births rates. The drop in births however, began three years before the marketing of the pill, and investigators are almost unanimous in the opinion that the development of new birth control methods has very little to do with the drop in birth rates.*

8/ J. C. Ridley and M. C. Sheps, "An Analytic Simulation Model for Human Reproduction with Demographic and Biological Components", Population Studies, Vol. XIX (1966), 297-310.

* Further, the proportion of childless or one-child marriages has decreased from 46% in the 1920's to 20% of married couples today in spite of the drop in the birth rate.

Norman Ryder of the University of Wisconsin and Charles Westoff of Princeton University recently declared in a joint report, "..... unintended births will decline with the rise in education, the improvement of contraceptive methods, the diminution of Roman Catholic resistance to effective means of fertility regulation, and the increase in government assistance to family planning."[9/]

Even so, many experts in the area believe that couples will ultimately have as many children as their parents but will spread the childbearing out over a longer span of years.[10/] And even if it were possible to establish functional, quantitative relationships between the variables quoted by Ryder and Westoff and birth rates, there still remains the problem of projecting births using the basic, hard-core statistics of population, marriages, parity, birth intervals, etc. If these variables may be considered as basic predictors, then the more theoretical determinants of Ryder and Westoff must await another generation of development in methods of projecting births.

9/ Address given at Annual Meeting, Population Association of America, Cincinnati, Ohio, April, 1967.

10/ The National Observer, May 8, 1967.

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